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# **Development of an Arctic Low Frequency Ambient Noise Model**

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## **LONG-TERM GOAL**

Our long-term goal is to develop a low frequency ambient noise model capable of predicting extreme (loud/quiet) noise events in Arctic ice-covered waters due to the presence or absence of storms.

## **OBJECTIVES**

We wish to determine the internal stress of the ice canopy covering the Arctic ocean due to convergent atmospheric forcing and relate this to energy dissipation rate due to ridge building, the major source of ambient noise in the frequency regime under consideration.

## **APPROACH**

At our request the Navy's Polar Ice Prediction System (PIPIS) has been modified to produce daily plots of energy dissipation rate over the ice-covered Arctic for the one-year period of the SHEBA experiment. We have analyzed ambient noise (AN) data from two ice-mounted buoys inserted near the SHEBA site and related changes in AN to changes in energy dissipation rate to test our hypothesis that energy dissipation, due to intense ice fracturing (ridge building) caused by migrating polar storms, is related to the source level density of the measured ambient noise. We have used high resolution differential radar images (RGPS) to corroborate the change in ice structure with changes in atmospheric forcing and ambient noise.

## **WORK COMPLETED**

PIPS energy dissipation rate plots for 1997-98 have been acquired from NRL-SSC. Similarly, RGPS ice deformation plots have been obtained from JPL.

Much effort was spent on editing the two ambient noise records. Spectral, temporal and spatial coherencies have been determined and related to results from previous years (primarily AIDJEX data).

Noisy and quiet AN events, from both summer and winter, have been examined with regard to atmospheric forcing and subsequent ice motion. The noise records during these events have been analyzed to establish their correlation with local or remote ice deformation (from RGPS) and energy dissipation rate (from PIPS).

## **RESULTS**

The ambient noise level measured during the winter of 1997-98 was exceptionally low, being similar to values measured in summer. The reduced noise level is a consequence of the strong cyclonic atmospheric regime present over the Arctic during the 1990's which reduced the number and intensity of storms migrating across the Beaufort Sea. in winter. Also contributing was the much thinner ice and reduced ice concentration resulting from the warming associated with several years of dominance by the cyclonic atmospheric regime. The highest AN levels occurred in winter when storms passed closely to the SHEBA site causing the ice field (motion) to undergo periods of convoluted, eddy-like motion. RGPS imagery and PIPS energy dissipation rate were highly correlated with these noisy events. Forcing from distant storms in winter also caused the low frequency component of AN to rise appreciably. This situation often showed little local ice deformation from RGPS but PIPS indicated high levels of energy dissipation present near the storm center that propagated over long distances with little attenuation. During summer PIPS energy dissipation and RGPS deformation were not effective indicators of AN due to the more open nature of the ice pack (which achieved record setting proportions during summer 1998), which prevented any buildup of internal energy and caused random motion of the field of individual ice floes.

## **IMPACT/APPLICATIONS**

Our model output is designed to assist submarines when operating beneath the Arctic ice cover. Submarine tactics related to detection/counter detection are strongly dependent on the magnitude of the noise field.

We have also demonstrated that a high resolution, directional ambient noise model can be used inversely to locate regions of high ridging intensity which has operational significance for submarines. In addition, the new PIPS 3.0 model, with its high resolution energy dissipation and divergence fields, should be able to identify regions of open water/thin ice and ridge formation. Knowledge of the areal extent of such features should provide more accurate estimations of the atmosphere-ice-ocean heat exchange as well as direct operational support to submarine, ice camps, etc.

## **TRANSITIONS**

None at the moment, but great potential exists for creation on an operational ambient noise forecast for ice-covered waters.

## **RELATED PROJECTS**

Our modeling effort is indirectly related to the larger scale project to replace and dramatically improve the current PIPS model. This improved model, known as PIPS 3.0, is a community effort lead by Bert Semtner at NPS and Ruth Preller at NRL/SSC.

## **PUBLICATIONS**

Bourke, R. H., D. Feller and J. H. Wilson, Ambient Noise Characteristics of the Nansen Basin, submitted to J. Acoust. Soc. Am., 1999.

Shaw, R. R. Jr., Ambient Noise Characteristics during the SHEBA Experiment, Master's thesis, Naval Postgraduate School, Monterey, March 2000.